Area A LNAPL Remedy Pilot Study
Multiphase Extraction (MPE)
General Scope of Work

Village of Hartford
Hartford, Illinois

1.0 PURPOSE

The primary purpose of the Area A Pilot Test is to confirm or modify as warranted the site-wide design parameters outlined in the USEPA approved 90% design package. These design parameters are necessary for the site-wide implementation of the LNAPL remedy. The test design will focus on validating assumptions and establishing reasonable ranges for selected individual design parameters by replicating the full-scale LNAPL extraction processes over a limited area and time frame.

Parameters and assumptions to be evaluated or otherwise confirmed include:

- Technology selection (i.e., two-phase extraction versus low flow dual-phase extraction);
- Area formation, LNAPL and hydrogeologic characteristics (i.e., hydraulic conductivity, transmissivity of LNAPL and water, permeability, water table fluctuations);
- Effective operating ranges (i.e., optimal air flow, vacuum, water/product/vapor production, and stinger and/or pump placement and extraction rates);
- System influence (i.e., radius of influence, radius of capture, and zone of influence); and
- Well construction parameters.

To accomplish these objectives, a series of tests will be performed. The tests will be scheduled to limit the influence of one test on another due to changes in site conditions as a result of the pilot study (e.g., LNAPL saturation near wells.)

This document presents a general scope of work for the pilot tests. The scope is intended to be flexible to allow adjustments during testing to accommodate conditions encountered in the field. As such, durations and activities identified herein are guidelines that may be modified in the field in accordance with best professional judgment.

2.0 TECHNOLOGY DESCRIPTION

The two technologies to be tested are **two phase extraction (TPE)** and **low flow dual phase extraction (DPE)**. TPE consists of the simultaneous extraction of groundwater, LNAPL and vapor **via a single entrainment tube** (aka a stinger or drop tube) as a result of the application of vacuum to that entrainment tube. DPE consists of the simultaneous extraction of groundwater, LNAPL and vapor **via a submersible pump to extract liquids and an entrainment tube under vacuum to extract vapor**. Both techniques are types of **multiphase extraction (MPE**), which is the general term for all forms of this technology that consist of vacuum enhanced removal of groundwater, LNAPL and vapor simultaneously (see attached technology diagram).

3.0 PILOT-TEST SETUP

The proposed LNAPL recovery system for Area A will be a MPE system that can be operated in either two-phase extraction (TPE) or low-flow dual phase extraction (DPE) mode. Currently, Area A facilities consist of one MPE zone with a subgrade vapor liquid separator (VLS), five extraction wells, and associated piping and other equipment. Multiple monitoring point wells are also present in Area A and will be utilized to obtain critical radius of influence (ROI) data during testing. The monitoring points have been spaced around MPE-A001 at varying distances and directions in order to provide the required ROI data. MPE-A001 will therefore be the primary pilot test extraction well (see attached map).

The Area A subgrade VLS has been tied into the existing Hartford Working Group (HWG) mitigation soil vapor extraction (SVE) system. The SVE system will apply vacuum to the extraction well during the test and provide vapor abatement for vacuum induced vapor generation during the tests. As described in previous correspondence to the Village of Hartford (dated November 3, 2008 and copied to USEPA), recovered liquids will be separated from the associated vapor flow in the subgrade VLS. The liquids will be pumped from the subgrade VLS to temporary LNAPL/water separation and storage equipment located on Premcor property in the Village of Hartford. Further details regarding liquid handling and disposal/recycling are provided in the aforementioned correspondence.

During the TPE testing, well MPE-A001 will be equipped with a stinger pipe that can be placed such that it withdraws primarily LNAPL, with some associated water generation. The depth of the stinger can be adjusted, allowing flexibility to accommodate fluctuations in groundwater table elevation and to increase or decrease drawdown. The wellhead will be equipped with a valve to regulate dilution/assist air and with gauges for measuring both applied vacuum and casing vacuum.

During the DPE testing, well MPE-A001 will be setup in a similar manner, however a pneumatic pump will be placed in the well such that it can pump both LNAPL and water. The stinger will be raised and used to apply vacuum to the well primarily for vapor extraction. Depending upon field response and fluid levels, the stinger may also be lowered to extract LNAPL.

In addition to the MPE pilot testing, an aquifer pumping test will also be conducted using well MPE-A001 and the associated monitoring points. During aquifer testing a pump will be placed in well MPE-A001 and the well will be open to the atmosphere. The same monitoring point wells utilized to obtain ROI data from the TPE and DPE pilot tests will be utilized to obtain aquifer drawdown data during the aquifer testing.

Pressure transducers will be utilized, where possible, to obtain well liquid level and vacuum readings. If a transducer cannot be installed in a well, then manual data collection at that well will be performed to obtain liquid level and vacuum readings. In addition, periodic manual measurements of liquid levels and vacuum will be performed to verify transducer performance. Prior to initiation of the tests, the transducers will be tested side by side to verify acceptable calibration consistency.

4.0 TESTING PROTOCOL

Two types of LNAPL extraction pilot tests will be performed during the study including TPE and low-flow DPE, along with LNAPL bail down tests and aquifer tests. The technologies and tests are discussed below.

TWO-PHASE EXTRACTION

As noted previously, TPE consists of the simultaneous removal of groundwater, LNAPL, and soil vapor via the application of vacuum through an extraction tube, frequently referred to as a “drop tube” or “stinger.” Because extraction occurs through a single stinger for a given well, there are several operating parameters that affect performance. Directly controllable parameters include:

- applied vacuum (pump, stinger, and well head vacuums);
- stinger depth;

- stinger diameter;
- stinger tip configuration; and
- supplemental atmospheric bleed air (used to modify the air/liquid ratio being extracted).

Indirectly controllable parameters include:

- water production rate;
- LNAPL production rate; and
- vapor production rate.

To evaluate well response (vapor and liquid recovery) under varying vacuum levels, a series of step tests (performed at MPE-A001) will be conducted during which the applied vacuum is modified in a step-wise, deliberate procedure. Generally the vacuum level applied to the wellhead is started at a low level and gradually increased as the test proceeds. The testing can be repeated for various stinger depths and supplemental bleed air configurations. The results will help identify the combination of operating configurations and parameters that support effective LNAPL extraction rates. Parameters to be varied during the single well TPE step test are outlined in Table 1.

Table 1. TPE Step Test Parameters

Parameter	***Minimum***	***Maximum***
Well Head Vacuum	10 in H2O	150 in H2O
Stinger Immersion % (in LNAPL)	50% (not < 0.5 ft.)	150% (not > 4 ft.)
Supplemental bleed air inflow	Closed	100% Open
Stinger Tip Configuration	Various	Various

NOTES: Stinger immersion percentage is the percentage of total LNAPL thickness measured in the well into which the stinger is inserted.

A limited range of combinations of these parameters will be implemented, and all indirectly controllable production parameters will be monitored. The Step Tests will initially be performed in the direction of increasing vacuum level and immersion depth, and upon reaching the maximum desired test level, will then be reversed in the decreasing direction to confirm test data is repeatable.

Following completion of the step test, an extended single well test at MPE-A001 will be conducted utilizing the optimal operating configuration identified during the step test as a starting point. The sustained, single well TPE test will run for up to 10 days to establish sustainable production level estimates for groundwater, LNAPL, and soil vapor. Surrounding monitoring point wells will be measured periodically to determine liquid drawdown and vacuum measurements. LNAPL / water / vapor production ratios will be monitored to determine production ratios and decay curves, if any are observed.

DUAL-PHASE EXTRACTION

Low-flow DPE consists of the simultaneous, but separate, extraction of groundwater, LNAPL, and soil vapor. Groundwater and LNAPL are typically removed via one or more submersible pumps while vapor is typically extracted by the application of vacuum at the well head. Previous low-flow DPE pilot tests conducted at the adjacent Premcor site demonstrated that optimal low-flow DPE recovery rates range from approximately 6 to 8 gallons per minute of total liquids production (groundwater and LNAPL).

As a technology comparison with TPE, a sustained, single-well, low-flow DPE test will be performed at extraction well MPE-A001 following completion of the sustained, single well TPE test. A pneumatic pump will be utilized to extract groundwater and LNAPL during the DPE pilot test. The depth of the pump and the applied vacuum may be varied initially to identify optimal operating parameters. Surrounding monitoring point wells will be measured periodically to determine liquid drawdown and vacuum ROI measurements. LNAPL / water / vapor production ratios will be monitored to determine production ratios and decay curves, if any are observed.

The sustained, single-well, low-flow DPE test, like the TPE test, is scheduled to last for up to 10 days to obtain ROI data and to estimate sustainable production levels for groundwater, LNAPL, and soil vapor. These results will be compared to the results of the sustained TPE test to ensure that the technology selected is appropriate.

BAIL DOWN TESTING

Bail Down testing of selected Area A wells will be performed in order to evaluate LNAPL Transmissivity (LNAPL T) values in between each test to provide a baseline for comparability of results. Due to the relatively high LNAPL T values for these wells, a pump rather than a bailer will be utilized to extract LNAPL. LNAPL recharge values will be obtained manually utilizing an electronic interface probe (EIP). The recharge data will be analyzed to calculate LNAPL T values for each well tested.

AQUIFER TESTING

Drawdown aquifer testing will be performed from well MPE-A001 in order to evaluate local aquifer physical characteristics (e.g., hydraulic conductivity) and potential anisotropy in the shallow Main Sand. A submersible pump will be installed in MPE-A001 in order to perform this test. Adjacent monitoring point wells will be monitored to obtain drawdown values resulting from the test. Barometric pressure fluctuations and, to the extent determinable, local water table fluctuations resulting from natural and anthropogenic forces will be measured to isolate pumping induced drawdown values. The data will be analyzed utilizing industry standard pumping test analytical methods appropriate for this aquifer.

SEQUENCING

Single well TPE step and sustained tests will be conducted initially, followed by the single well low-flow DPE test, and finally, the aquifer test. An LNAPL bail down test, used to determine the LNAPL transmissivity, will be conducted initially and after each test to evaluate test impact on LNAPL recoverability in the vicinity of the test well and to evaluate comparability of the results of the various tests.

The TPE step test is scheduled to last for up to three days. The TPE and low flow DPE tests will each last for up to 10 days (total of up to 20 days for both). The aquifer test will be performed for a minimum of 24 hours up to a maximum of 3 days.

5.0 DATA COLLECTION AND STORAGE

The pilot testing described herein will generate a significant amount of data. As indicated previously, Level TROLL® and BaroTROLL® transducers will be installed in extraction and observation wells. The transducers are capable of recording liquid levels and pressure/vacuum readings inside the wells. Wells will be manually gauged at least once per day to validate the transducer data. Several manual field measurements will also be recorded including measurements taken at the well heads, at manifold vaults, and at system equipment. The variables recorded during the low-flow DPE events vary somewhat from those recorded during TPE events.

Manual data will be collected by field personnel and logged on forms outlining the data to be collected and at what frequency. Manual data will be collected at well heads, manifold vaults, the subgrade vapor/liquid separator vault, and at various pieces of downstream system equipment. Electronic data will be logged automatically from various liquid level and pressure transducers placed inside the extraction and observation wells. Once logged, the data will be stored temporarily in the equipment dataloggers and downloaded periodically to a laptop computer or handheld recorder in the field.

6.0 DATA ANALYSIS

Following completion of the testing, the data will be analyzed to remove external influences such as barometric pressure and local/regional aquifer level variations that may result from either natural or anthropogenic water table fluctuations. Subsequently, a variety of analyses will be performed, including (but not necessarily limited to):

1. Aquifer pumping test analysis for aquifer characteristics
2. Sustainable LNAPL / Water / Vapor production ratios and decay curves
3. Radius of Influence from the TPE and low flow DPE tests to include liquid drawdown and vacuum influence
4. Analysis of Radius of Influence (ROI), Radius of Capture (ROC), and associated Zone of Influence (ZOI) for the two technologies
5. Analysis of LNAPL Transmissivities
6. Reporting

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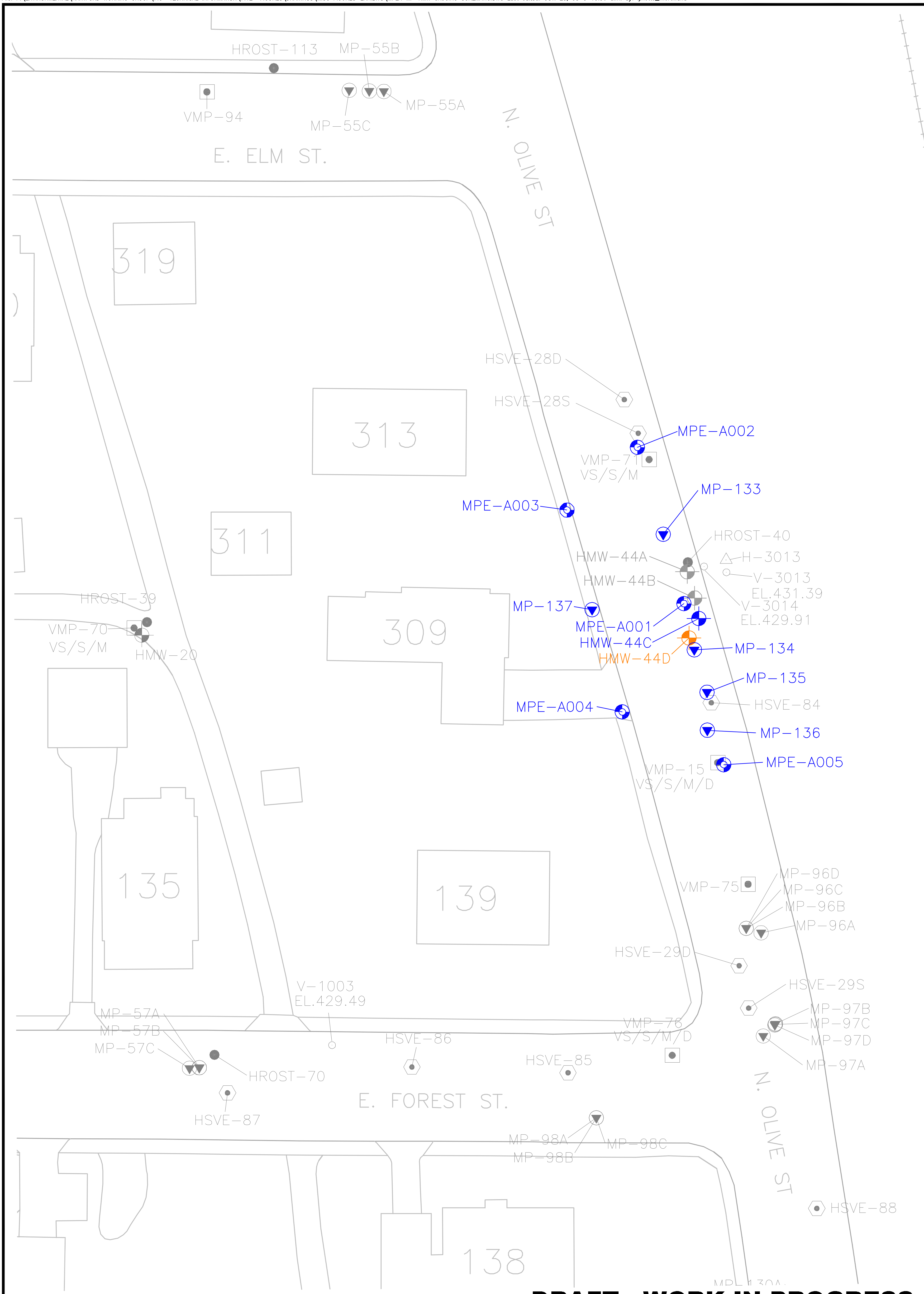

DRAFT - WORK IN PROGRESS

LEGEND

- MONITORING POINTS – MANUALLY GAUGED WEEKLY
- MULTIPHASE EXTRACTION WELLS – MANUALLY GAUGED WEEKLY
- GROUNDWATER MONITORING WELLS – MANUALLY GAUGED WEEKLY
- GROUNDWATER MONITORING WELLS – TRANSDUCER DOWNLOADED MONTHLY

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SCALE FEET

HARTFORD WORKING GROUP HARTFORD, IL	PROJECT NO. 21561955
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DRN. BY:lrm 10/28/08 DSGN. BY:ss CHKD. BY:bh — Gauging Schematic	FIG. NO. 1

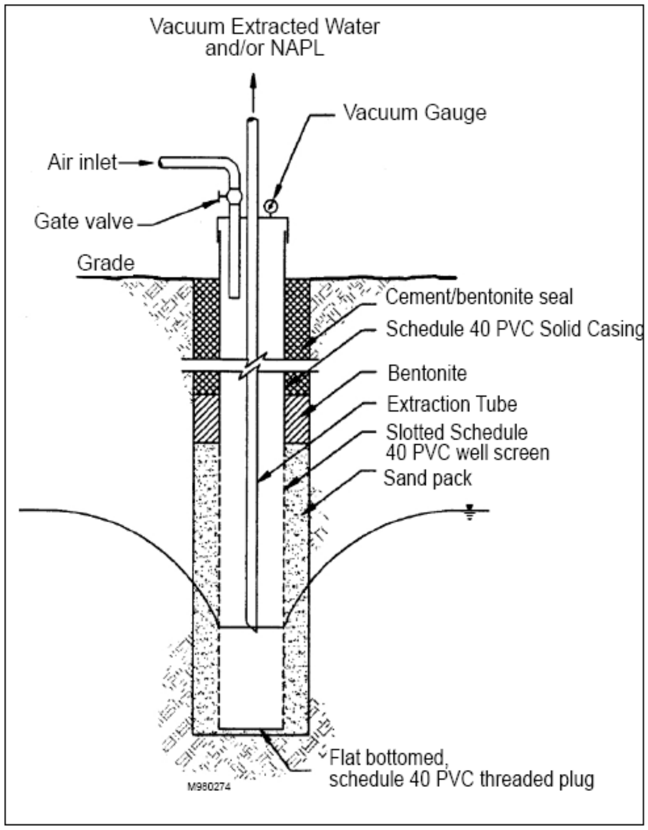

Figure 4-2. Two-Phase Extraction Well. (After EPA 1995)

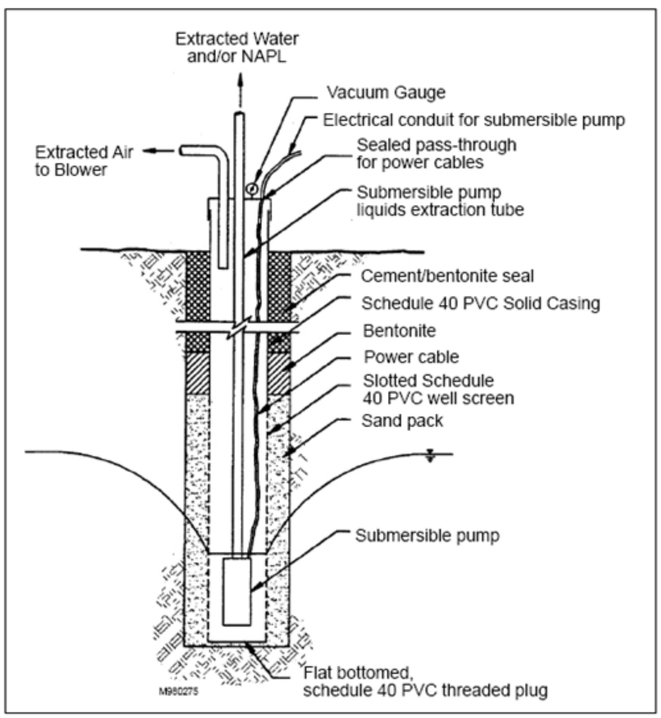

Figure 4-1. Dual-Phase Extraction Well. (After EPA 1995)